Simultaneous Test of Graphic Recorders (KR-2000 and KR-3000) with I/O Stimulator

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1.0 INTRODUCTION

A nuclear safety-grade graphic recorder is a microprocessor-based digital recorder that provides detailed operation information to operators of nuclear power plants. A nuclear safety-grade graphic recorder display on a 5.6 inch LCD screen the operation information such as input data (temperature, pressure, flow, power, and water level) from physical quantities directly. A real-time display can be possible for bar graphs, trends and other form of information. It also stores the measurement data in its own external storage device. The past recorded data can be retrieved at the required time and the trend of the past and present values can be displayed. The data can be compared and analyzed simultaneously on the same screen. Typical main functions are the display, alarm, arithmetic, setting, recording and other functions. A nuclear safety-grade graphic recorder shall meet the following functional and performance requirements.

o Screen updated once per second
o Within 125ms (scan and sampling)
o Accuracy: ± 0.1 Full Range
o Ensure safety of recorded data
o Data collection within 10 seconds in case of power supply fail.

In addition, the nuclear-safety grade graphic recorder shall satisfy the following three safety function attributes.

o Unknown Event Monitoring using Watch Dog Timer(WDT)
o Self diagnostic and alarm output
o Administrator password and security function

We have automatically tested whether the main functions of the original graphic recorder are operating correctly by using an I/O simulator, which were previously tested by one by one. At this time, two models were tested at the same time. The first model is the KR-2000 graphic recorder and the second model is the KR-3000 graphic recorder. Both were tested at the same time; additionally, the testbed setup, the test case, the test configuration, and cabling were setup under the same conditions. The I/O Simulator is an NI-PXI-based analog, digital I/O system, with each input/output module mounted on a PXI system and wired with an SCB-68 connector block. For the automatic test, the commercial LabVIEW application program was used and the input and output each module were controlled and measured. The KR-2000 recorder has a total of 12 channels. The KR-3000 recorder has a total of 48 channels. Simultaneous test was carried out for a total of 60 channels under the 1S cycle triangle signal generation during 24 hours continuously. The test conditions used were equal to the recording cycle and the accuracy of commercial nuclear power plants.

2.0 Simultaneous target test with I/O Simulator

2.1 Hardware Configuration

I/O Simulator test equipment is required for simultaneous target testing of KR-2000 graphic recorder and KR-3000 graphic recorder. The I/O Simulator test equipment is the same as the one that performed the FLC (for example, FPGA-based Logic Controller[1]) system test before because the difference in the subject, re-configuration such as testbed setup, test case, test configuration and cabling are required. The I/O simulator is an NI-PXI-based analog, digital input and output system, with each input and output module mounted on a PXI system and wired with an SCB-68 connector block. We used commercial LabVIEW application and controlled the input and output of each module. The I/O simulator test device main component configuration details are shown in Table 1 and the hardware configuration diagram is shown in Figure 1.

Table1. Configurations of I/O Simulator Test Device Major Parts

Items	Quantity	Comments
NI-PXIe 8135	1EA	2.3 GHz Quad-Core PXI Express Controller
NI-PXIe 1075	1EA	8 hybrid slots, 8 PXI Express slots, and 1 PXI Express system timing slot embedded chassis
NI-PXI 6511	1EA	64 channel sync / source digital input
NI-PXI 6512	1EA	64 channel source digital output
NI-PXIe 6363	2EA	32 channel analog input
NI-PXI 6239	1EA	8-channel high-speed analog input

NI-PXI 6733	1EA	8-channel high-speed analog output
NI-PXI 6704	1EA	16 channel voltage, current output
SCB-68	4EA	I / O connector block for DAQ devices with 68-pin connector

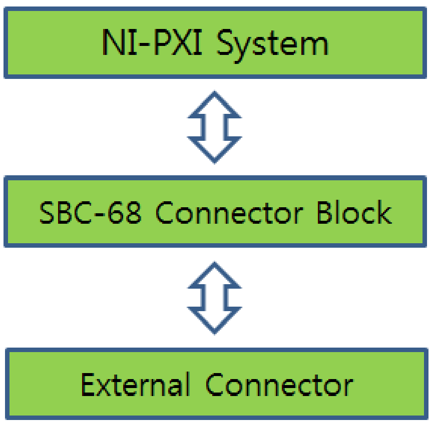

Fig. 1. Hardware Configuration Diagram

2.2 Software Configuration

We created an application program based on the commercial LabVIEW program. The application program executes the function of control and measurement based on each I/O module connected to the PXI. They also generate signals and store the result of the measured data.

The signal is generated by both a closed loop and an open loop. An internal signal source and an external signal source are shown in Figure 2 and Figure 3, respectively

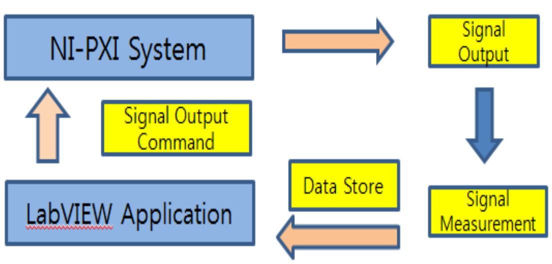

Fig. 2. I/O Stimulator Output from inside source

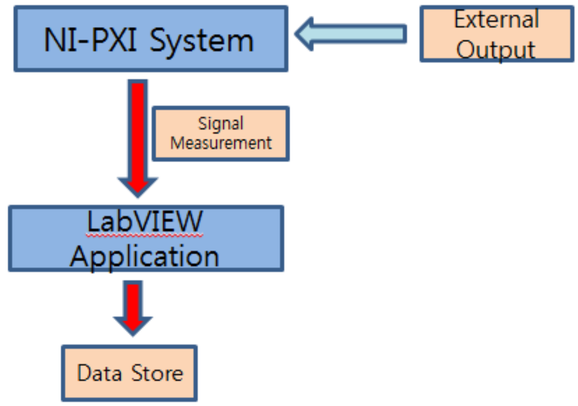

Fig. 3. I/O Stimulator Output from outside source

2.3 Target Testing

KR-2000 and KR-3000 using an I/O stimulator have been tested. Test results were also recorded under the same conditions with Yokogawa. The two target records and referenced record of Yokogawa are recorded simultaneously. After the test is done, it was compared two target records and reference recorder (Yokogawa). One channel signal source from I/O stimulator assigned to four target channels, which means KR-2000 were connected three groups (4x3=12), KR-3000 were connected 12 groups (4X12=48). Twelve (12) and three (3) equals fifteen (15). We used fifteen signal sources from I/O stimulator. Target test graphic recorders (KR-2000 model and KR-3000 model) connected with I/O stimulator are shown in Figure 4. The KR-2000 recorder has a total of 12 channels and the KR-3000 recorder has a total of 48 channels. Simultaneous test was carried out for a total of 60 channels about a 1 cycle triangle signal generation for 24 hours continuously. The test conditions were setup equal to the recording cycle and accuracy of domestic commercial nuclear power plants. The connection diagram of the target items is shown in Figure 5.

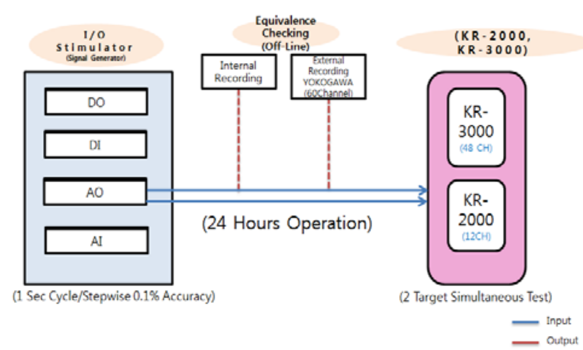

Fig. 4. Connection diagram between target test recorder (KR-2000 and KR-3000 with I/O Stimulator

The input tag signal from KR-2000 and KR-3000 were connected 15 cabling groups from an I/O stimulator because numbers of signals were so many. One channel signal source from I/O stimulator assigned to four target channels, which means KR-2000 were connected three group (4x3=12), KR-3000 were connected 12 group (4X12=48). Twelve (12) and three (3) equals fifteen (15). Fifteen means total signal sources from I/O stimulator as shown in Figure 5.

Fig. 5. Simultaneous testing of KR-2000 recorder and KR-3000 recorder

3.0 Results

The result of the simultaneous continuous test of KR-2000 graph recorder and KR-3000 graph recorder is shown in Figure 6. It can get result values from comparison result value of external recording device. Both were tested PASS under 1S triangle signal generation successfully. The left screen in Figure 6 is the result of the target KR-2000 and KR-3000.

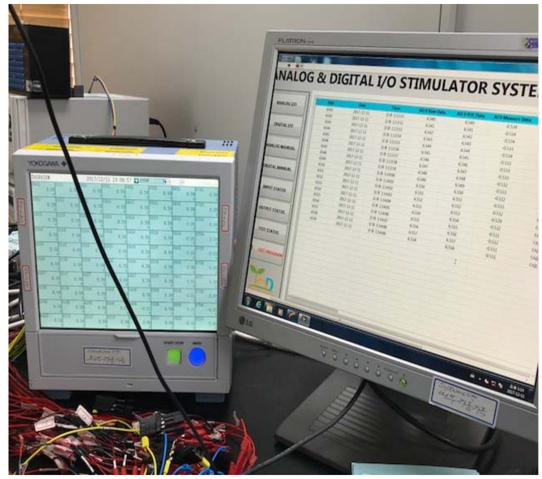

Fig. 6. Test result screen of KR-2000 recorder and KR-3000 recorder

4.0 Conclusion

The test conditions setup were equal to the recording cycle and the accuracy of commercial nuclear power plants. The KR-2000 graphic recorder and the KR-3000 graphic recorder were tested and verified to record consecutively for a long term period of time under 0.1% accuracy at 1 second. Further tests will be made at 100ms condition.

NOMENCLATURE

AI : Analog Input
AO : Analog Output
DI : Digital Input
DO : Digital Output
I/O : Input/Output
KR : Korea
LCD : Liquid Crystal Display
NI-PXI : National Instruments-PCI eXtensions for Instrumentation
SCB-68 : Shielded I/O Connector Block

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